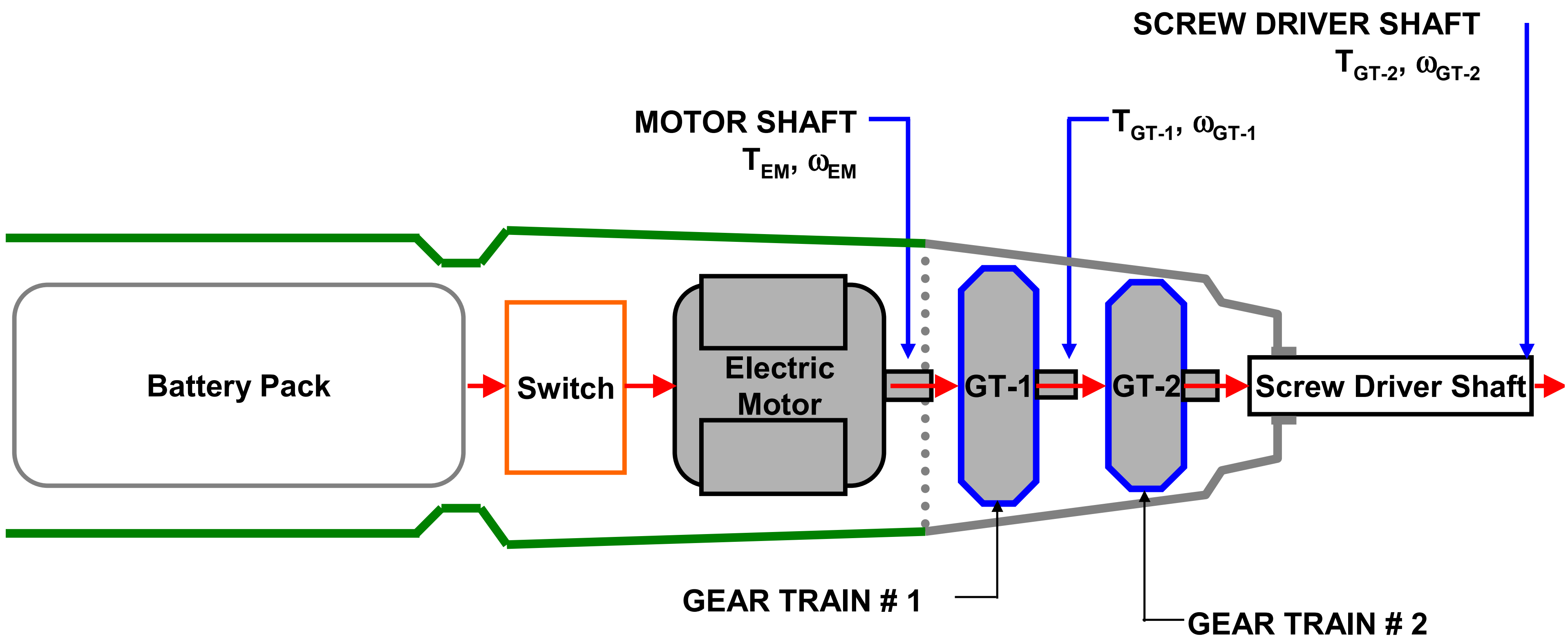
2.000 Planetary Gear Application & Derivation

Cordless Screw Driver:



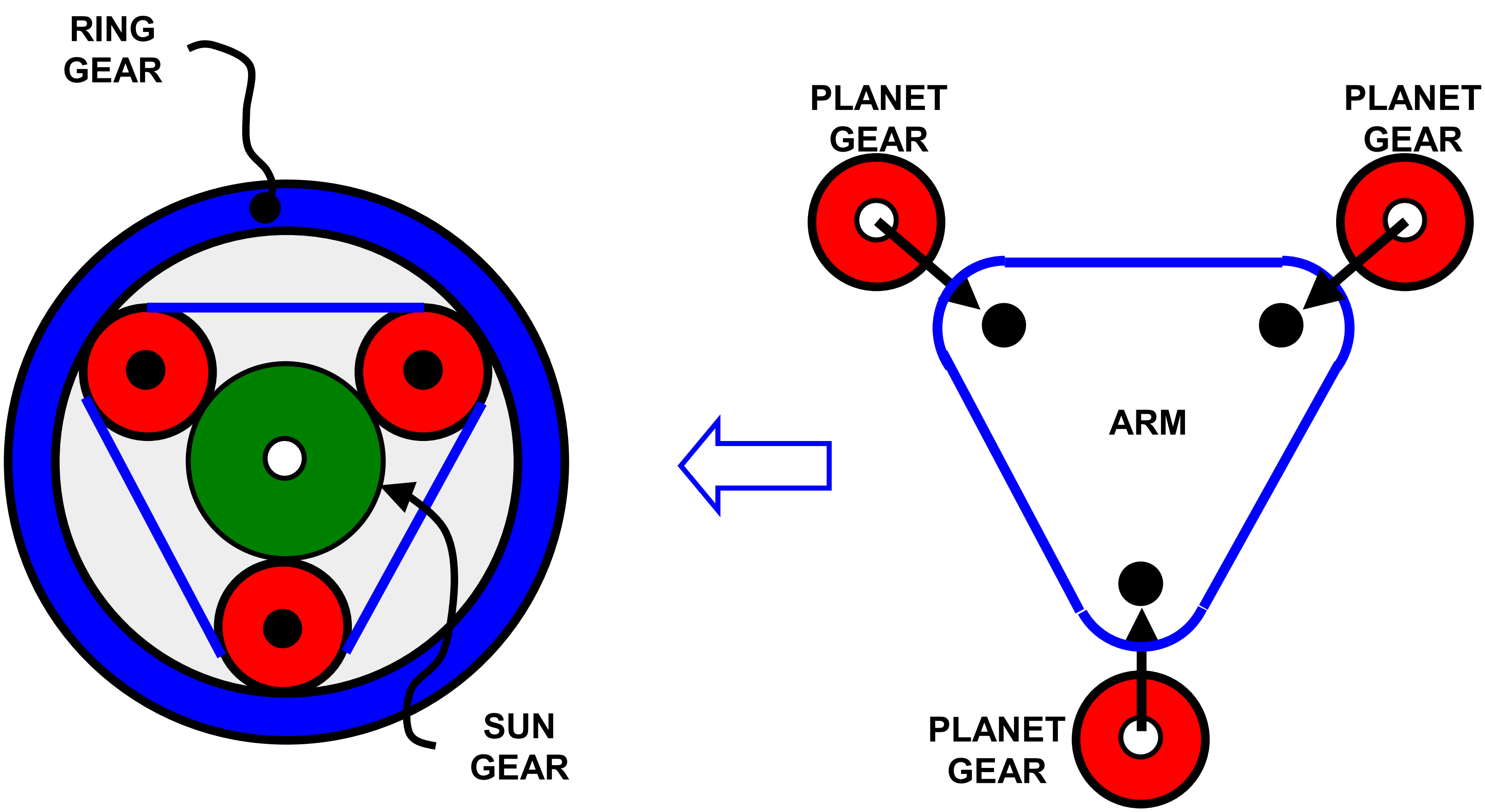
Cross Section of **Power** Flow Through Cordless Screw Driver

Planetary Gear Components

Planetary gear trains consist of the following:

- 1 Ring gear 1 or more planet gear(s) 1 Sun gear 1 Arm

Legend:



Cordless Screw Driver Gear Trains

Special Gear Set: Planetary gear trains consist of the following:

- 1 Ring gear   1 or more planet gear(s)   1 Sun gear   1 Arm

How a planetary gear train functions (analogous to solar system)

- **Planetary gear systems have VERY small/large train ratios and are very compact**
- **The** sun gear **is located at the center of the gear train "solar system"**
- **The** arm **carries the planet gears in "orbit" around the sun gear**
- **The** planet gears **"orbit" on the inside of the** ring gear

Screw driver gear trains

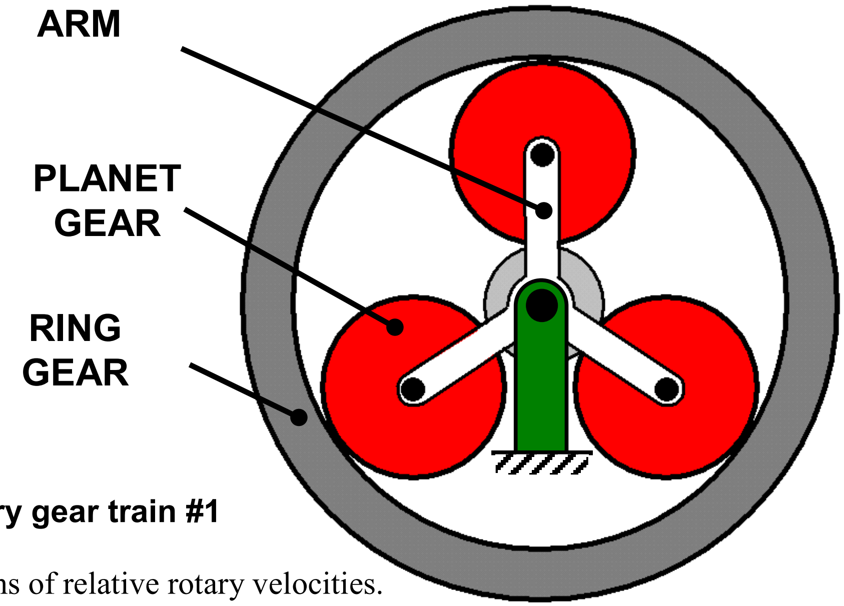
Motor Gear (Sun Gear-1)

Arm 1 Gear (Sun Gear-2)

GEAR TRAIN # 1

GEAR TRAIN # 2

Screw Driver Planetary Gear Characteristics



Nomenclature

- N_i = Number of teeth on gear i
- ω_i = Rotational speed of gear i

Subscripts

- 1 = Component in planetary gear system # 1
- 2 = Component in planetary gear system # 2
- s = Sun gear
- p = Planet gear
- r = Ring gear
- a = Arm

Example: N_{s1} = Number of teeth on sun gear in planetary gear train #1

This is a complicated mechanism to solve. The easiest way is to work in terms of relative rotary velocities.

$$\frac{\omega_{ri}}{\omega_{si}} = \frac{\text{Speed of ring gear with respect to the arm}}{\text{Speed of sun gear with respect to the arm}} = \frac{\omega_{ri} - \omega_{ai}}{\omega_{si} - \omega_{ai}}$$

Now we consider the sun gear as the input and the ring gear as the output. To determine the train ratio between the two gears, we use the following:

Because sun gear and ring gears rotate in opposite directions

$$e_i = \frac{\omega_{ri}}{\omega_{si}} = \frac{\text{Product of Driving Teeth}}{\text{Product of Driven Teeth}} = \frac{-N_{si}\,N_{pi}}{N_{pi}\,N_{si}} = \frac{-N_{si}}{N_{ri}} = \frac{\omega_{ri} - \omega_{ai}}{\omega_{si} - \omega_{ai}} \rightarrow \boxed{\omega_{ai} = \frac{\omega_{ri}\,N_{ri} - \omega_{si}\,N_{si}}{N_{ri} + N_{si}}}$$

We can use the result for the speed of the arms to solve for combined planetary gear trains. We begin by solving for the speed of the arm in the first gear train. Note that the speed of the first arm = speed of the second sun gear (they are both part of the same piece). We then use the same equation to solve for the second arm velocity. Note the arm is connected to the screw driver shaft, so the second arm velocity = the screw driver shaft velocity. This procedure is more clearly outlined on the following page.

Solving For the Screw Driver Train Ratio

GIVEN:

Gear Teeth

$N_{s1} = 6$ | $N_{p1} = 19$ | $N_{r1} = 48$ | $N_{s2} = 6$ | $N_{p2} = 19$ | $N_{r2} = 48$

Train Equation(s)

$$\omega_{ai} = \frac{\omega_{ri} N_{ri} - \omega_{si} N_{si}}{N_{ri} + N_{si}}$$

PROCEDURE:

Write equations for Trains 1 & 2 → Solve for ω_{a2}, $\omega_{a2} = \omega_{SD\text{-}SHAFT}$ → Plug ω_{a1} into eqxn. for ω_{a2} → Train Ratio $= \dfrac{\omega_{SD\text{-}SHAFT}}{\omega_{motor}}$

HINTS:

$\omega_{s1} = \omega_{motor}$ — Motor gear is sun gear for first gear train

$\omega_{r1} = \omega_{r2} = 0$ — Ring gears do not move

$\omega_{s2} = \omega_{a1}$ — Sun gear for 2nd train sits on arm of first train